BA

PATENT ABSTRACTS OF JAPAN

(11)Publication number : **09-093008**

(43)Date of publication of application : **04.04.1997**

(51)Int.CI. **H01P 5/16**

H01Q 13/08

H01Q 21/10

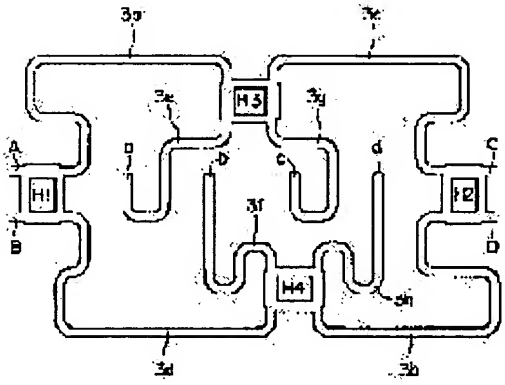
(21)Application number : **07-243504**

(22)Date of filing : **21.09.1995**

(71)Applicant : **NIPPON TELEGR & TELEPH CORP <NTT>**

(72)Inventor : **UEHARA KAZUHIRO**
KAGOSHIMA KENICHI
SEKI TOSHIHIRO

(54) BUTLER MATRIX CIRCUIT AND ANTENNA SYSTEM



(57)Abstract:

PROBLEM TO BE SOLVED: To prevent electric performance from being degraded by unwanted coupling between transmission lines for requiring an air bridge and to cancel the increase of production costs.

SOLUTION: Four output terminals a-d are arranged on one line at almost equal intervals and outside these four output terminals a-d, four hybrids H1-H4 and four transmission lines 3a-3d for mutually connecting these four hybrids H1-H4 are arranged so as not to cross. Concerning all the paths between four input terminals A-D and four output terminals a-d, the number of times of curving transmission lines 3a-3h is made equal.

CLAIMS

[Claim(s)]
[Claim 1] In the Butler matrix circuit which consists of four hybrids and four input terminals which were formed by the transmission line, and four output terminals It arranges so that the four transmission lines which connect four hybrids mutually may not be crossed. the four aforementioned output terminals -- almost -- regular intervals -- a single tier -- arranging -- arranging -- this -- the outside of four output terminals -- the four aforementioned hybrids -- this -- The Butler matrix circuit characterized by making equal the number of times of folding of the transmission line about all the paths between the four aforementioned input terminals and four output terminals.
[Claim 2] The Butler matrix circuit according to claim 1 characterized by forming by the transmission line which opened four output terminals wide.
[Claim 3] Antenna equipment which is antenna equipment which consists of a Butler matrix circuit according to claim 1 and four radiating elements, and is characterized by connecting the four aforementioned radiating elements to four output terminals, respectively.
[Claim 4] the antenna equipment which consists of the Butler matrix circuit according to claim 2, four coupling slots, and four radiating elements -- it is -- four radiating elements -- four coupling slots -- respectively -- minding -- four opening -- the antenna equipment characterized by carrying out the electromagnetic coupling to 4 output terminals formed of the transmission line the bottom, respectively
[Claim 5] Antenna equipment according to claim 4 with which each of four radiating elements is characterized by the bird clapper from at least two radiating elements connected in series.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] Especially this invention is used for the antenna for radio communications systems or the antenna for instrumentation systems of a microwave band and a millimeter wave band, and relates to the suitable Butler matrix circuit and antenna equipment.
[0002]
[Description of the Prior Art] Drawing 5 is drawing showing the example of composition of conventional antenna equipment. In this drawing, a sign 1 is the Butler matrix circuit formed of the microstrip line or the TORIPU rate track, and is constituted by hybrids H1-H4, input terminal A-D, output terminal a-d, phase shift circuits 6A and 6B, and the transmission line 3 that connects these circuit elements. Moreover, Signs 10A-10D are radiating elements, and one is connected to the above-mentioned output terminal a-d, respectively so that it may illustrate.
[0003]
[Problem(s) to be Solved by the Invention] By the way, with such conventional antenna equipment, since four hybrids H1-H4 formed on the 1 flat surface in the Butler matrix circuit, four input terminal A-D, four output terminal a-d, and four radiating elements 10 are connected and constituted from the transmission line 3, Intersections 7A and 7B arise in two places so that it may illustrate. For this reason, in these intersections 7A and 7B, since an air bridge was needed, the electric performance deteriorated by unnecessary combination between the transmission lines, and there was a problem that a manufacturing cost also became high.
[0004] Furthermore, in the four transmission lines 3 which connect the four above-mentioned hybrids H1-H4 mutually, since the number of times of folding of the transmission line differed by 2 of an outside, and 2 of the inside, dispersion in an extraneous emission or an insertion loss arose, the electric performance deteriorated and there were a frequency band and a trouble of becoming narrow.
[0005] In case it constitutes the Butler matrix circuit which constitutes antenna equipment on 1 flat surface, it was made in view of the trouble mentioned above, and intersection of the transmission line does not arise, and further, an electric performance is good and aims [the air bridge of this invention is unnecessary, and its manufacturing cost is low, and it also has neither the unnecessary combination between the transmission lines, nor dispersion between terminals, and] it at offer of the latus Butler matrix circuit of a frequency band, and antenna equipment.
[0006]

[Means for Solving the Problem] In the Butler matrix circuit which consists of four hybrids and four input terminals in which invention according to claim 1 was formed by the transmission line, and four output terminals It arranges so that the four transmission lines which connect four hybrids mutually may not be crossed. the four aforementioned output terminals -- almost -- regular intervals -- a single tier -- arranging -- arranging -- this -- the outside of four output terminals -- the four aforementioned hybrids -- this -- About all the paths between the four aforementioned input terminals and four output terminals, it is characterized by making equal the number of times of folding of the transmission line.
[0007] Invention according to claim 2 is characterized by forming by the transmission line which opened four output terminals wide in invention according to claim 1.
[0008] Invention according to claim 3 is antenna equipment which consists of a Butler matrix circuit according to claim 1 and four radiating elements, and is characterized by connecting the four aforementioned radiating elements to four output terminals, respectively.
[0009] the antenna equipment with which invention according to claim 4 consists of the Butler matrix circuit according to claim 2, four coupling slots, and four radiating elements -- it is -- four radiating elements -- four coupling slots -- respectively -- minding -- four opening -- it is characterized by carrying out the electromagnetic coupling to 4 output terminals formed of the transmission line the bottom, respectively
[0010] Invention according to claim 5 is characterized by the bird clapper in invention according to claim 4 from at least two radiating elements to which each of four radiating elements was connected in series.
[0011]
[Function] An insertion loss can also be made small, while an air bridge becomes unnecessary and the excitation amplitude of the antenna radiating element by the unnecessary combination between these transmission lines and dispersion of an excitation phase shift are made small, since intersection is not produced in the transmission line which connects between four input terminals and four output terminals in case the Butler matrix circuit which constitutes antenna equipment is constituted on 1 flat surface according to this invention. Moreover, since the number of times of folding of all the transmission lines that connect between four input terminals and four output terminals is equal, dispersion in an extraneous emission or an insertion loss is small, and the excitation amplitude of an antenna radiating element and dispersion of an excitation phase shift are small, and a frequency band can also be made large.
[0012]
[Embodiments of the Invention] Hereafter, the operation gestalt of this invention is explained with reference to a drawing. Drawing 1 is drawing showing the 1st operation gestalt, and shows the gestalt which formed the Butler matrix circuit which constitutes antenna equipment by the microstrip line. For signs H1-H4, in this drawing, a hybrid and 3a-3h are [an input terminal and a-d of the transmission line and A-D] output terminals.
[0013] four output terminal a-d is mostly put in order and arranged to a single tier at equal intervals so that it may illustrate -- having -- the outside of this output terminal a-d -- four hybrids H1-H4 -- this -- the four transmission lines 3a-3d which connect four hybrids H1-H4 mutually are formed, and the Butler matrix circuit which the intersection which are the transmission lines 3a-3h does not produce at all is realized
 [0014]

An insertion loss can also be made small, while an air bridge is unnecessary, and making small the excitation amplitude of the antenna radiating element by the unnecessary combination between these transmission lines, and variation of an excitation phase shift and being able to carry out the thing of them by adopting such composition.

[0015] Moreover, among the transmission lines 3a-3d which connect the four above-mentioned hybrids H1-H4 mutually, transmission-line 3a and transmission-line 3b are formed so that electric length may become equal, and transmission-line 3c and no less than 3d of transmission lines are formed so that electric length may become equal. That is, the difference of the electric length of the transmission lines 3a and 3b and transmission lines [3c and 3d] electric length constitutes the phase shift circuit from this composition in equivalent.

[0016] Furthermore, on circuitry, although it is necessary to bend the transmission lines 3a-3h several times, they form all of the transmission lines [3a-3d] number of times of folding so that it may become 5 times equally, and they form all the number of times of folding about the transmission lines 3e-3h so that it may become 4 times equally. By these, dispersion in an extraneous emission or an insertion loss can be made small, and a frequency band can also be made large.

[0017] Next, the 2nd operation form of this invention is explained. drawing 2 -- this -- it is drawing showing the 2nd operation form, and four radiating elements are connected to the Butler matrix circuit explained with the 1st operation form mentioned above, and antenna equipment is constituted In addition, about the same component as the component explained by above-mentioned drawing 1 , the same sign is attached and the explanation is omitted.

[0018] In this drawing, it is the transmission line connected to four output terminal a-d to which Signs 10A-10D correspond a radiating element, and 11A-11D correspond radiating elements 10A-10D, respectively. Radiating elements 10A-10D are carried out by arbitrary antenna simple substance elements, such as for example, a micro-stripe antenna, a dipole antenna, or a horn antenna. Moreover, the transmission lines 11A-11D are carried out by the arbitrary transmission lines, such as a microstrip line or a coaxial track.

[0019] Drawing 3 is drawing showing the 3rd operation form of this invention. the Butler matrix circuit explained by above-mentioned drawing 1 with this 3rd operation form -- setting -- four output terminal a-d -- opening -- the bottom -- the transmission line -- constituting -- each of four more coupling slots -- minding -- this -- four opening -- the antenna equipment which carried out the electromagnetic coupling of the four radiating elements on the track the bottom, respectively is shown In addition, about the same component as the component explained by above-mentioned drawing 1 or drawing 2 , the same sign is attached and the explanation is omitted.

[0020] The output terminal which constituted sign a' - d' from the transmission line opened wide in this drawing, and 12A-12D show the coupling slot, and 13A-13D show the electromagnetic coupling. The electromagnetic coupling of the radiating elements 10A-10D is carried out to output terminal a' which corresponds through coupling slots 12A-12D - d', respectively. These coupling slots 12A-12D are carried out by the slot of arbitrary configurations, such as for example, a rectangular slot or a circular slot.

[0021] Finally, drawing 4 is drawing showing the 4th operation form. This 4th operation form shows the antenna equipment using the radiating element to which at least two (this

operation form three) were connected in series in the antenna equipment which was explained with the operation form of the above 3rd and which carried out electromagnetic-coupling excitation.
[0022] In this drawing, Signs 14A-14D show the radiating element to which three were connected in series. The electromagnetic coupling of the radiating elements 14A-14D is carried out to output terminal a' which corresponds through coupling slots 12A-12D - d', respectively.
[0023] These radiating elements 14A-14D are carried out by using a microstrip line etc. in the resonance direction of for example, a micro-stripe antenna, and connecting in series. It is possible to obtain a large antenna frequency band by shifting respectively slightly the resonance frequency of three micro-stripe antennas connected in series here.
[0024] Moreover, an electromagnetic coupling performs excitation through coupling slots 12A-12D among three radiating elements connected in series to at least one. Thus, by forming, the directivity of the resonance direction of an antenna can be easily fabricated with easy excitation structure.
[0025]
[Effect of the Invention] According to this invention, the following effects are done so as explained above.
(1) Since intersection does not arise in the transmission line which connects between four input terminals and four output terminals in case the Butler matrix circuit which constitutes antenna equipment is constituted on 1 flat surface, it is possible for an air bridge to become unnecessary and to make a manufacturing cost low.
(2) Since the excitation amplitude of the antenna radiating element by the unnecessary combination between the transmission lines and dispersion of an excitation phase shift are made small, adjustment of an excitation distribution becomes unnecessary.
(3) Since an insertion loss can be made small, it is possible to make efficiency of an antenna high.
(4) Since the number of times of folding of all the transmission lines that connect between four input terminals and four output terminals is equal, dispersion in an extraneous emission or an insertion loss is small, and since the excitation amplitude of an antenna radiating element and dispersion of an excitation phase shift can be made small, adjustment of an excitation distribution becomes unnecessary.
(5) the thing with a large frequency band for which it comes out and distortion is made small in broadband transmission is possible

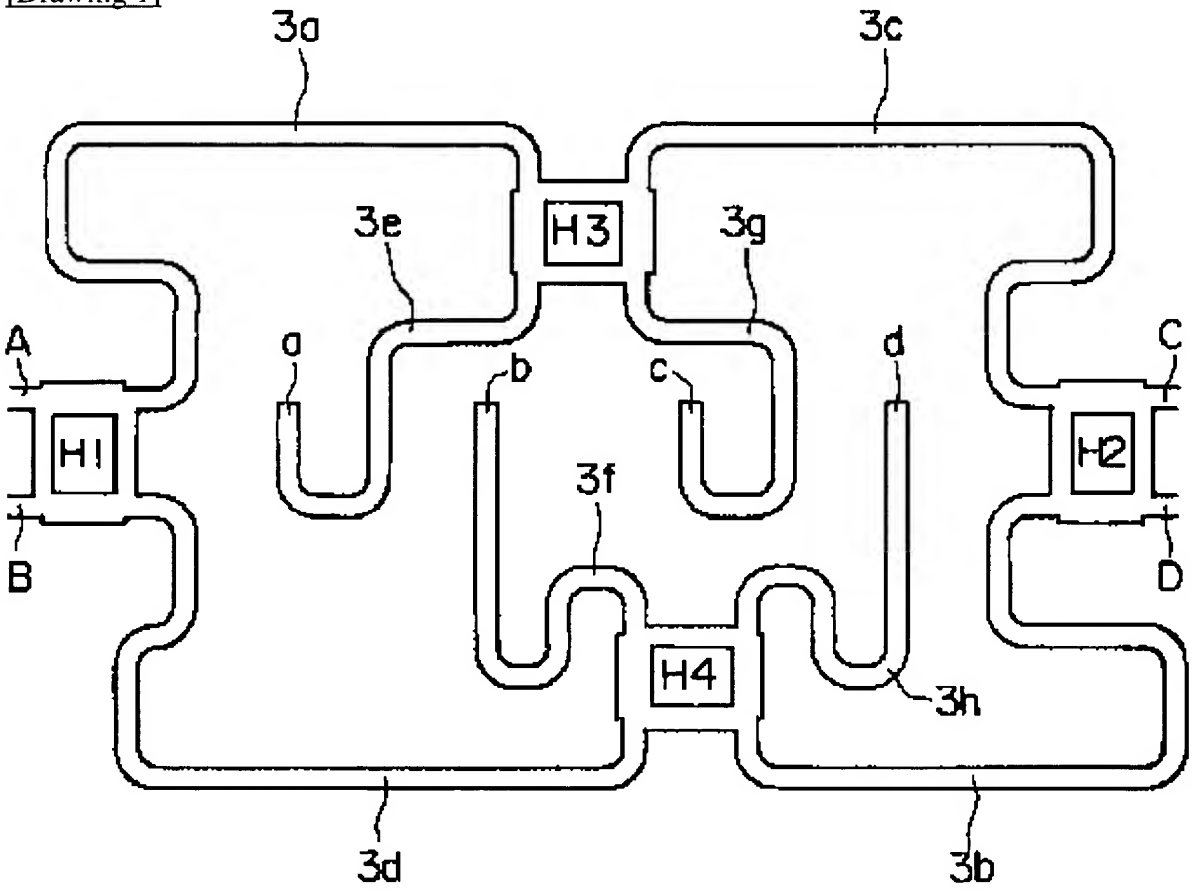
---

[Translation done.]

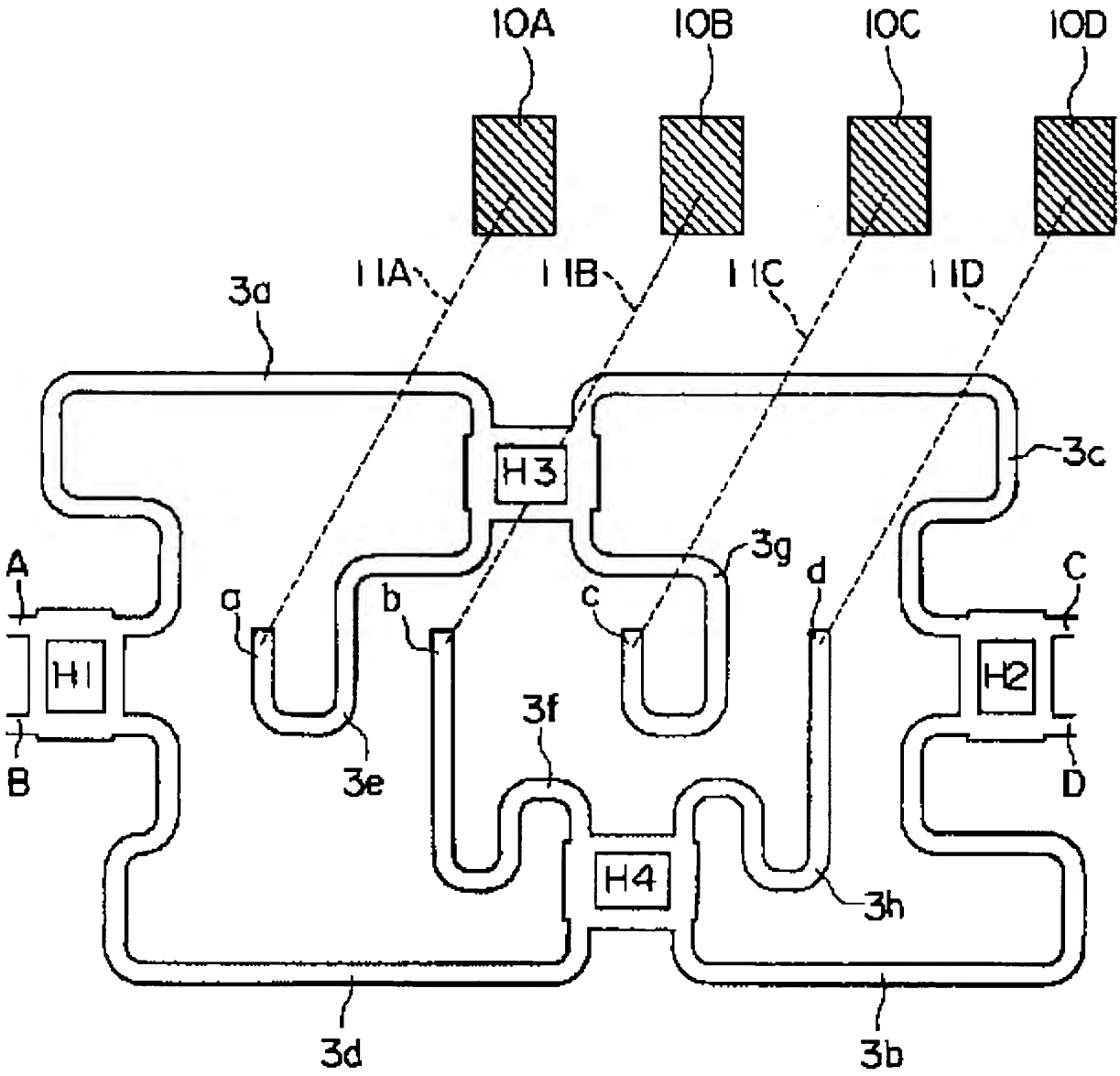
* NOTICES *

DRAWINGS

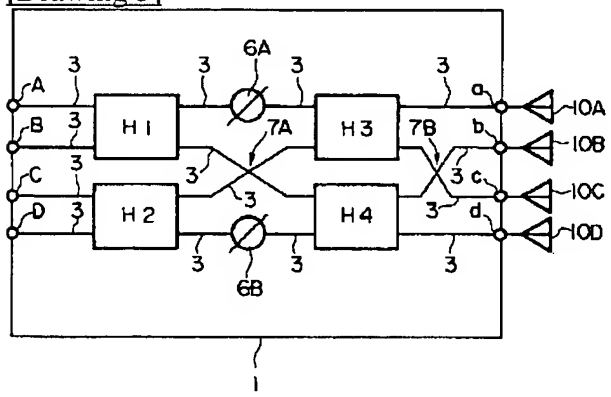
[Drawing 1]



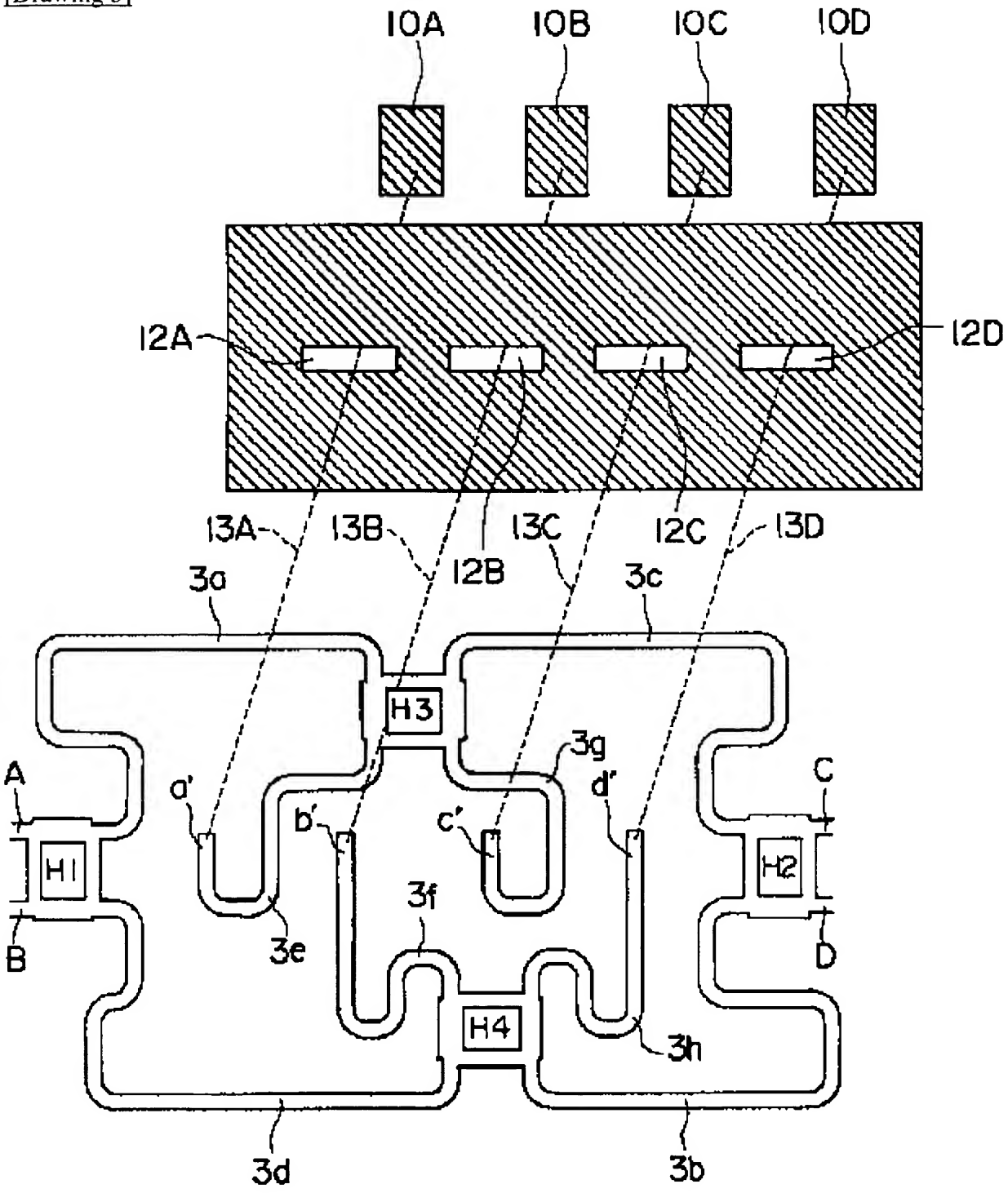
[Drawing 2]


10A
10B
10C
10D
11A
11B
11C
11D
3a
3c
H3
3g
A
a
b
c
d
C
H1
H2
3f
3e
B
D
H4
3h
3d
3b

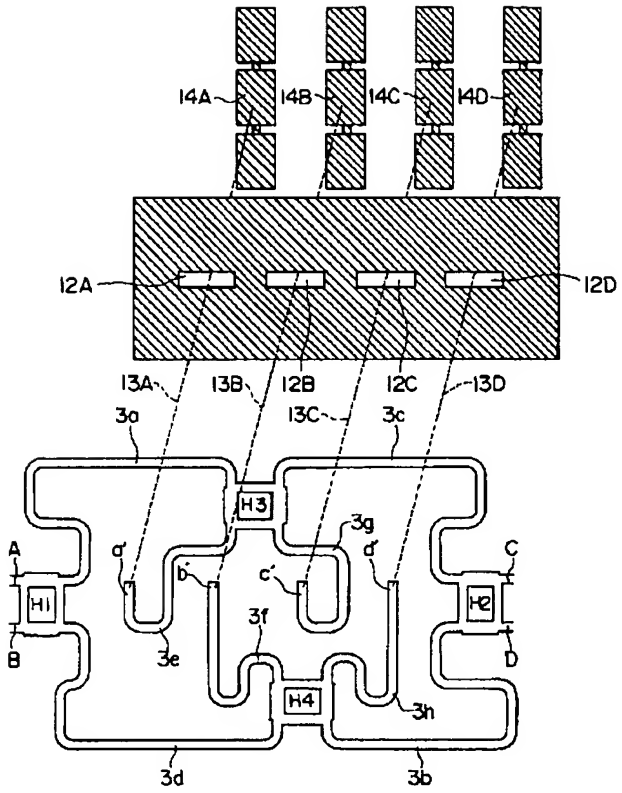
[Drawing 5]


6A
A
B
C
D
H1
H2
H3
H4
7A
7B
a
b
c
d
10A
10B
10C
10D
6B
1

[Drawing 3]



[Drawing 4]



[Translation done.]